FINAL REPORT

CAMPAIGN IV

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Flash Hydropyrolysis of Prince Mine Coal

for

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EXECUTIVE SUMMARY

FLASH HYDROGENPYROLYSIS OF PRINCE MINE COAL

A series of nine flash hydropyrolysis tests were made on Prince Mine coal and one additional run was made on straight Forestburg coal. The equipment was modified for this campaign to allow the runs to be carried out at a higher pre-heat temperature (850°C) at the same pressure (1850 psi), and to measure accurately the internal temperature of the reaction zone at various points. The modifications made to the equipment to accomplish the objectives were:

The preheater tube material was changed to Inconel 617 from the previous Inconel 604 type.

The char trap was enlarged.

The gas sampling ports on the reactor that were not previously used, were modified to accept thermocouples.

The consistency of the run results as shown in the tables that form part of this report plus the ease of operation of the modified system, confirm the values of the modifications for this campaign and those to be run in the future.

Table 1 - Gas Temperatures

Run No.		67	68	69	70	71	72	73	74	75
React. Heaters 'on'	#	3	3	3	3	3	2	4	4	4
Preheat	C	715	752	820	855	808	806	807	814	808
Between 1 and 2	C	660	687	740	778	735	738	740	766	738
Between 2 and 3	C	677	712	763	816	762	750	762	784	770
Between 3 and 4	C	657	690	734	778	738	593	756	769	765
Between 4 and Trap	C	510	520	530	586	540	441	702	719	708
Discharge	C	445	460	470	525	478	380	650	665	655

Nine runs are shown due to the caking of the feed on the tenth run. In this run a finely ground flyash of <2 microns was used as a diluent. The action of this material was much inferior to the Cab-O-Sil diluent used in the other tests due to its greater ability to be wetted by the volatiles in the coal as they are initially produced.

Table 2 shows the material balance of the runs 67 to 75. The feed for the first seven runs was as follows: Prince Mine Coal 57% : Forestburg Coal 40% : Cab-O-Sil 3%. The feed for Run 74 was 100% Forestburg and the feed for Run 75 was 90% Prince Mine Coal and 10% Cab-O-Sil.

Table 2 Material Balance

Test #		67	68	69	70	71	72	73	74	75
Coal Mix Feed	g	583.4	966.4	983.2	972.6	875.5	935.4	984.5	998.7	985.8
Hydrogen	g	880	1412	1342	1276	1294	1505	1401	678	1646
MAF Coal in Feed	g	512.9	849.6	864.4	855.1	769.7	822.4	865.6	888.4	764.3
Diluent in Feed	g	70.5	116.7	118.8	117.5	105.8	113.0	118.9	0	98.6
Total Feed	g	1463.4	2378.4	2325.2	2248.6	2169.5	2440.4	2385.5	1676.7	2631.8
Discharge Hydrogen	g	845.9	1365.8	1331.4	1204.1	1263.6	1470.3	1378.6	658.4	1686.3
Liquid Hydrocarbon	g	47.3	66.8	96.2	17.9	93.7	73.0	104.2	42.5	44.6
Liquid Water	g	131.7	188.3	178.8	195.7	163.8	198.1	219.0	226.1	47.9
Hydrocarbon gases	g	161.5	334.1	338.0	419.5	282.8	271.9	297.8	222.9	319.8
Char	g	276.9	423.3	381.0	411.3	365.6	427.2	385.9	526.8	533.2
Total Discharged	g	1463.3	2378.3	2325.4	2248.5	2169.5	2440.5	2385.5	1676.7	2631.8
Liquid HC	% MAF Coal	9.2	7.9	11.1	2.1	12.2	8.9	12.0	4.8	5.8
Water	% MAF Coal	25.7	22.2	20.7	22.9	21.3	24.1	25.3	25.5	6.3
Hydrocarbon gases	% MAF Coal	31.5	39.3	39.1	49.1	36.7	33.1	34.4	25.1	41.8
Char	% Coal Mix Feed	47.5	43.8	38.8	42.3	41.8	45.7	39.2	52.7	54.1
Nominal Temp	^{o}C	700	750	800	850	800	800	800	800	800
Nominal Pressure	p.s.i.	1850	1850	1850	1850	1850	1850	1850	1850	1850
Nominal Particle Residence	s	6.4	6.5	5.6	5.4	5.5	3.7	7.3	7.3	7.2

Table 3 shows the production of the oil phase in more detail. The temperatures given are the average temperatures measured in the hot zone and can be regarded as the actual reaction temperature.

Table 3 - Liquid Hydrocarbon Analyses

Run No.	67	68	69	70	71	72	73	74	75
Temperature ^{o}C	665	696	746	791	745	744	740	760	745
Benzene Wt %	28.99	64.99	88.17	93.15	91.05	94.31	97.31	95.99	-
Toluene Wt %	16.79	3.41	0.53	0.24	0.62	0.29	0.16	0.16	-
Xylene Wt %	3.23	0.69	0.08	0.39	0.10	0.05	0.04	0.04	-
Naphthalene Wt %	21.74	25.13	8.40	4.17	8.33	4.96	2.30	2.17	-

These results are very consistent and indicate that the changes made to the F.H.P. apparatus led to an improved ease of operation and consistency.

1. INTRODUCTION

Campaign No. IV was intended to continue the work done in Campaign III on Prince Mine Coal. The recommendations made in the previous Campaign were carried out prior to the start of the tests in order to gain a) a better measurement of the inside temperatures and to reach b) higher temperatures without exceeding the safety limit of the Inconel pre-heat tube. Further safety was promulgated by installing a pressure sensor on the reactor chamber, this decreased the possibility of sharp increases of pressures going unnoticed, due to plugging of the gas outlet lines by fine coal particles. The char trap was also increased in size so that a larger weight of the Prince Mine coal mixture can be run. This is due to the fluffiness and larger volume of the char produced.

2. OBJECTIVE

To run no more than ten flash hydropyrolysis tests on a Prince Mine coal mixture, established in Campaign III, at a series of temperatures and particle residence times to maximise the liquid produced. A comparison run of 100% Forestburg coal was also to be made.

3. TEMPERATURE MEASUREMENT

Increasing the number of internal thermocouples improved the accuracy of measurement of reactor temperatures. This can be seen in Table 1 which gives the internal temperatures of the reactor at different points and shows the lag in temperature from the pre-heat to the points between each reactor heater.

Table 1 - Internal Gas Temperatures

Run No.		67	68	69	70	71	72	73	74	75	76
React. Heaters 'on'	#	3	3	3	3	3	2	4	4	4	A
Preheat	C	715	752	820	855	808	806	807	814	808	B
1 and 2 Htr.	C	660	687	740	778	735	738	740	766	738	O
2 and 3 Htr.	C	677	712	763	816	762	750	762	784	770	R
3 and 4 Htr.	C	657	690	734	778	738	593	756	769	765	T
4 and ch. Trap	C	510	520	530	586	540	441	702	719	708	E
Discharge	C	445	460	470	525	478	380	650	665	655	D

4. COAL FEED

The feed for the first seven runs, 67 to 73 inclusive, consisted of: Prince Mine coal - 57%; Forestburg coal - 40%; Cab-O-Sil - 3%. The latter was a silica fume of sub-micron size which aided the flowability of the mix through the critical sticking temperature. The feed for Run No. 74 was 100% Forestburg coal (of substantially the same size as the Prince Mine coal) and Run No. 75 was 90% Prince Mine coal with 10% Cab-O-Sil mixed with it. Run No. 76 contained 90% Prince Mine coal with 10% of a finely ground flyash of <2 microns. This latter test failed due to caking in the the upper portion of the reactor tube. This is probably due to the tendency of the carbonaceous fly-ash to be wetted by the volatiles as they are initially produced at the critical temperature.

5. TEST PROTOCOL

Tests 67 to 70 inclusive were run at constant pressure, 1850 p.s.i., and equal particle residence times, 5.4 to 6.5 seconds. The temperature of reaction was changed to a nominal 700, 750, 800, 850°C which represented actual reaction temperatures of 677, 712, 763 and 816°C (temperatures noted between No. 2 and No. 3 heaters). The best run at 763°C, No. 69, was duplicated in No. 71 at a temperature of 762°C. In Runs 72 and 73 the temperature and pressure were kept the same (750 and 762°C) and 1850 p.s.i. but the residence times were varied, Run 72 at 3.7 seconds and Run 73 at 7.3 seconds. The remaining two runs were carried out at 1850 p.s.i., 784°C and 770°C respectively and 7.3 and 7.2 seconds respectively.

6. ANALYSES OF FEED AND PRODUCTS

The chemical analyses were conducted by Standard Biological Laboratories Bioceutical Research a Division of SGS Supervision Services.

TABLE 2

Coal sample - Run 67 - Analysis method A.S.T.M.

Cab-O-Sil %	Coal Mix	Prince Mine	Forestburg
Ash %	12.08	13.86	11.05
Carbon %	62.70	68.97	61.58
Hydrogen %	3.77	3.63	4.21
Oxygen %	13.44	8.85	21.66
Nitrogen %	1.43	1.82	1.18
Sulphur %	1.7	2.87	0.32
Cab-O-Sil %	3.0	-	-

TABLE 3

Char samples - A.S.T.M. Method
N.B. Analyses performed on a dry basis.

Run 67	Ash %	C %	H %	O %	N %	S %
Run 67	25.82	73.34	2.63	4.30	0.92	2.4
Run 68	23.78	73.62	2.61	3.16	1.45	1.7
Run 69	26.39	70.06	2.12	2.94	1.45	1.6
Run 70	27.33	71.05	2.03	2.86	1.37	2.3
Run 71	26.53	70.45	2.23	2.77	1.43	1.7
Run 72	25.30	71.38	2.30	3.57	1.01	1.7
Run 73	28.75	70.54	2.05	2.92	1.34	1.3
Run 74	13.63	69.21	3.06	11.98	1.84	0.64
Run 75	34.61	66.08	1.98	2.01	1.07	1.4

TABLE 4

Analyses of liquid samples - Traps 1 and 2 combined - A.S.T.M.

	Water %	Solids %	C %	H %	O %	N %	S %
Run 67	64.38	1.37	86.40	7.23	4.17	0.82	0.43
Run 68	62.27	10.00	91.58	7.50	0.87	0.56	0.12
Run 69	59.67	0.69	91.72	7.93	0.41	0.11	0.32
Run 70	89.79	0.67	91.94	7.67	0.74	<0.03	0.13
Run 71	58.21	0.06	91.30	7.94	0.88	0.08	0.07
Run 72	68.62	0.04	91.76	7.46	0.51	0.11	0.13
Run 73	60.55	2.34	91.78	7.95	0.67	<0.03	<0.01
Run 74	81.52	0.16	91.11	7.49	1.42	<0.03	0.10
Run 75	Nil	Nil	91.50	7.70	0.61	-	-

N.B. Water and solids % were done by centrifuging and reported as percent by volume.

TABLE 5

Analyses of liquids by G.C./A.S.T.M. test method.
The results are based on direct injection of the supernatant oily layer after centrifuging and reported as percent by weight.

	Benzene %	Toluene %	Xylene %	Naphthalene %
Run 67	28.99	16.79	3.23	21.74
Run 68	64.99	3.41	0.69	25.13
Run 69	88.17	0.53	0.08	8.40
Run 70	73.15	0.24	0.39	4.17
Run 71	91.05	0.624	0.10	8.33
Run 72	94.31	0.29	0.05	4.96
Run 73	97.314	0.162	0.04	2.30
Run 74	95.99	0.16	0.04	2.17
Run 75	-	-	-	-

MATERIAL BALANCE

The material balance has been corrected for losses by a proportional sharing between all the products.

TABLE 6

Test # 67	Grams	% of feed	% MAF Coal
Coal feed mix	583.4	39.9	-
Hydrogen	880.0	60.1	-
Moisture in feed	35.0	2.4	-
M. F. feed	548.4	37.5	-
Ash in feed*	89.4	6.1	-
MAF coal in feed	459.0	31.4	-
Total matl. fed	1463.4	100.0	-
Discharge hydrogen	845.9	57.8	-
Total org. liquids	47.3	3.2	10.3
Water in feed	35.0	2.4	-
Water from reaction	96.7	6.6	-
Total gases	161.5	11.0	35.2
Char	276.9	18.9	50.5 (% M.F. feed)
Total matl. dischd.	1463.3	100.0	-

* Value includes cab-o-sil in this and subsequent tables #'s 7,8,9,10,11&12,13&14

TABLE 7

Test # 68	Grams	% of feed	% MAF Coal
Coal feed mix	966.4	40.6	-
Hydrogen	1412.0	59.4	-
Moisture in feed	58.0	2.4	-
M.F. feed	908.4	38.2	-
Ash in feed	148.1	6.2	-
MAF coal in feed	760.3	32.0	-
Total matl. fed	2378.4	100.0	-
Discharge hydrogen	1365.9	57.4	-
Total org. liquids	66.8	2.8	8.8
Water in feed	58.0	2.4	-
Water from reaction	130.3	5.5	-
Total gases	334.1	14.0	43.9
Char	423.3	17.8	46.6 (% M.F. feed)
Total matl. dischd.	2378.4	100.0	-

TABLE 8

Test # 69	Grams	% of feed	% MAF Coal
Coal feed mix	983.2	42.3	-
Hydrogen	1342.0	57.7	-
Moisture in feed	59.0	2.5	-
M.F. feed	924.2	39.7	-
Ash in feed	150.6	6.5	-
MAF coal in feed	773.6	33.3	-
Total matl. fed	2325.2	100.0	-
Discharge hydrogen	1331.4	57.3	-
Total org. liquids	96.2	4.1	12.4
Water in feed	59.0	2.5	-
Water from reaction	119.8	5.2	-
Total gases	338.0	14.5	43.7
Char	381.0	16.4	41.2 (% M.F. feed)
Total matl. dischd.	2325.3	100.0	

TABLE 9

Test # 70	Grams	% of feed	% MAF Coal
Coal feed mix	972.6	43.3	-
Hydrogen	1276.0	56.7	-
Moisture in feed	58.4	2.6	-
M.F. feed	914.2	40.7	-
Ash in feed	149.0	6.6	-
MAF coal in feed	765.2	34.0	-
Total matl. fed	2248.6	100.0	-
Discharge hydrogen	1204.1	53.6	-
Total org. liquids	17.9	0.8	2.3
Water in feed	58.4	2.6	-
Water from reaction	137.4	6.1	-
Total gases	419.5	18.7	54.8
Char	411.3	18.3	45.0 (% M.F. feed)
Total	2248.5	100.0	

TABLE 10

Test # 71	Grams	% of feed	% MAF Coal
Coal feed mix	875.5	40.4	-
Hydrogen	1294.0	59.6	-
Moisture in feed	52.5	2.4	-
M.F. feed	823.0	37.9	-
Ash in feed	134.1	6.2	-
MAF coal in feed	688.8	31.8	-
Total matl. fed	2169.5	100.0	-
Discharge hydrogen	1263.6	58.2	-
Total org. liquids	93.7	4.3	13.6
Water in feed	52.5	2.4	-
Water from reaction	111.3	5.1	-
Total gases	282.8	13.0	41.1
Char	365.6	16.9	44.4(% M.F. feed)
Total	2169.5	100.0	

TABLE 11

Test # 72	Grams	% of feed	% MAF Coal
Coal feed mix	935.4	38.3	-
Hydrogen	1505.0	61.7	-
Moisture in feed	56.1	2.3	-
M.F. feed	879.3	36.0	-
Ash in feed	143.3	5.9	-
MAF coal in feed	736.0	30.2	-
Total matl. fed	2440.4	100.0	-
Discharge hydrogen	1470.2	60.2	-
Total org. liquids	73.0	3.0	9.9
Water in feed	56.1	2.3	-
Water from reaction	142.0	5.8	-
Total gases	271.9	11.1	36.9
Char	427.2	17.5	48.6 (% M.F. feed)
Total	2440.5	100.0	

TABLE 12

Test # 73	Grams	% of feed	% MAF Coal
Coal feed mix	984.5	41.3	-
Hydrogen	1401.0	58.7	-
Moisture in feed	59.1	2.5	-
M.F. feed	925.5	38.8	-
Ash in feed	150.8	6.3	-
MAF coal in feed	774.6	32.5	-
Total matl. fed	2385.5	100.0	-
Discharge hydrogen	1378.6	57.8	-
Total org. liquids	104.2	4.4	13.5
Water in feed	59.1	2.5	-
Water from reaction	159.9	6.7	-
Total gases	297.8	12.5	38.4
Char	385.9	16.2	41.7 (% M.F. feed)
Total	2385.5	100.0	

TABLE 13

Test # 74	Grams	% of feed	% MAF Coal
Coal feed mix	998.7	59.6	-
Hydrogen	678.0	40.4	-
Moisture in feed	59.1	3.5	-
M.F. feed	939.6	56.0	-
Ash in feed	110.4	6.6	-
MAF coal in feed	829.2	49.5	-
Total matl. fed	1676.7	100.0	-
Discharge hydrogen	658.4	39.3	-
Total org. liquids	42.5	2.5	5.1
Water in feed	59.1	3.5	-
Water from reaction	167.0	10.0	-
Total gases	222.9	13.3	26.9
Char	526.8	31.4	56.1 (% M.F. feed)
Total	1676.7	100.0	

TABLE 14

Test # 75	Grams	% of feed	% MAF Coal
Coal feed mix	985.8	37.5	-
Hydrogen	1646.0	62.5	-
Moisture in feed	34.2	1.3	-
M.F. feed	951.6	36.2	-
Ash in feed	221.5	8.4	-
MAF coal in feed	700.1	26.6	-
Total matl. fed	2631.8	100.0	-
Discharge hydrogen	1500.3	60.0	-
Total org. liquids	41.8	1.6	6.0
Water in feed	34.2	1.3	-
Water from reaction	10.7	0.4	-
Total gases	299.7	11.4	42.8
Char	499.6	19.0	52.5(% M.F. feed)
Total	2466.3	93.7	

* Since there is a large weight of material unaccounted for these figures have not been corrected.

Summary of the material balance

	67	68	69	70
Liquid hydrocarbons % MAF Coal	10.3	8.8	12.4	2.4
Water from reaction % MAF Coal	21.1	17.1	15.5	18.0
Hydrocarbon gases % MAF Coal	35.2	43.9	43.7	54.8
Char % Coal mix feed	50.5	46.6	41.2	45.0

	71	72	73	74	75
Liquid hydrocarbons % MAF Coal	13.6	9.9	13.5	5.1	6.0
Water from reaction % MAF Coal	16.2	19.3	20.6	20.1	1.5
Hydrocarbon gases % MAF Coal	41.1	36.9	38.4	26.9	42.8
Char % Coal mix feed	44.4	48.6	41.7	56.1	52.5

DISTRIBUTION OF ELEMENTS FOR RUNS 67 - 75

Run No.		67	68	69	70	71	72	73	74	75
Organic Liquids	-Carbon	11.3%	9.9%	14.5%	2.7%	15.5%	11.8%	16.3%	6.8%	6.2%
CH_4	-Carbon	19.5%	24.9%	31.9%	42.7%	29.6%	25.9%	30.2%	22.7%	30.4%
C_2H_4	-Carbon	1.7%	2.7%	1.2%	0.4%	0.8%	0.7%	0.2%	0.1%	0.2%
C_2H_6	-Carbon	9.2%	10.6%	6.0%	5.8%	5.7%	6.4%	5.1%	2.2%	4.3%
CO	-Carbon	1.9%	1.6%	1.7%	1.3%	1.7%	1.7%	1.7%	2.5%	1.1%
CO_2	-Carbon	0.2%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%
Char	-Carbon	56.2%	50.2%	44.7%	47.2%	46.8%	53.5%	46.5%	65.7%	57.9%
Discharge hydrogen	-H	93.6%	92.9%	92.7%	90.3%	93.3%	94.1%	93.2%	88.6%	94.7%
Organic liquids	-H	0.4%	0.3%	0.5%	0.1%	0.5%	0.3%	0.6%	0.4%	0.2%
Water in feed	-H	0.4%	0.4%	0.5%	0.5%	0.4%	0.4%	0.4%	0.9%	0.2%
Water from reaction	-H	1.2%	1.0%	0.9%	1.1%	0.9%	1.0%	1.2%	2.5%	0.1%
CH_4	-H	2.6%	3.5%	4.5%	6.6%	4.0%	3.2%	4.0%	5.8%	3.7%
C_2H_4	-H	0.1%	0.2%	0.1%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
C_2H_6	-H	0.9%	1.1%	0.6%	0.7%	0.6%	0.6%	0.5%	0.4%	0.4%
Char	-H	0.8%	0.7%	0.0%	0.6%	0.6%	0.6%	0.5%	1.6%	0.7%
Organic Liquids	-O	1.4%	0.3%	0.2%	0.1%	0.5%	0.2%	0.3%	0.1%	0.3%
Water in feed	-O	21.9%	26.1%	27.9%	26.4%	27.6%	24.2%	23.9%	22.0%	45.3%
Water from reaction	-O	60.5%	58.8%	56.7%	62.0%	58.5%	61.3%	64.7%	62.1%	14.2%
CO	-O	6.3%	6.7%	7.4%	5.5%	7.2%	6.3%	6.0%	8.0%	13.2%
CO_2	-O	1.5%	1.3%	0.4%	0.1%	0.2%	0.6%	0.0%	0.0%	0.4%
Char	-O	8.4%	6.8%	7.2%	6.0%	6.0%	7.4%	5.1%	7.9%	26.5%
Organic Liquids*	-N	5.1%	3.1%	0.8%	0.0%	0.7%	0.6%	0.2%	0.5%	0.3%
Char	-N	33.3%	46.9%	41.7%	42.7%	44.1%	34.1%	39.4%	47.9%	32.3%
Organic Liquids*	-S	2.2%	0.6%	1.9%	0.1%	0.5%	0.7%	0.1%	-	0.2%
Char	-S	71.0%	46.8%	38.9%	61.3%	44.3%	49.0%	31.8%	-	34.8%

7. THERMOGRAVIMETRIC ANALYSIS OF COAL AND CHAR (TEST #73)

Two samples of feed coal mix and char from test #73 were sent for thermogravimetric analysis (TGA) to determine weight loss of heating.

Experimental

Analysis was carried out using a Dupont 951 T. G. Analyzer. The samples were heated at 10 C/min. in an air atmosphere flowing at 100 cc/min.

TGA 1 and 2 show the Coal and Char 73, respectively.

The coal sample shows a weight loss occurring immediately. The sample lost 6.74% by 250°C. Between 250°C and 600°C, there was a gradual weight loss totalling 87.33%. By 600°C, the sample had levelled off indicating 12.67% inorganic material remaining. The area marked by the X indicates something in the sample was igniting. This was confirmed by running the sample a second time.

TGA 2, Char 73 shows one weight loss of 74.83% occurring between 421°C and 600°C. By 600°C, the sample has levelled off indicating 27.17% inorganic material.

Comparison pictures of the same coal mix and char from Run #73 are included. These show a distinct difference between the acicular raw coal and the more rounded char.

A. J. Last
Consultant
Mineral Resources

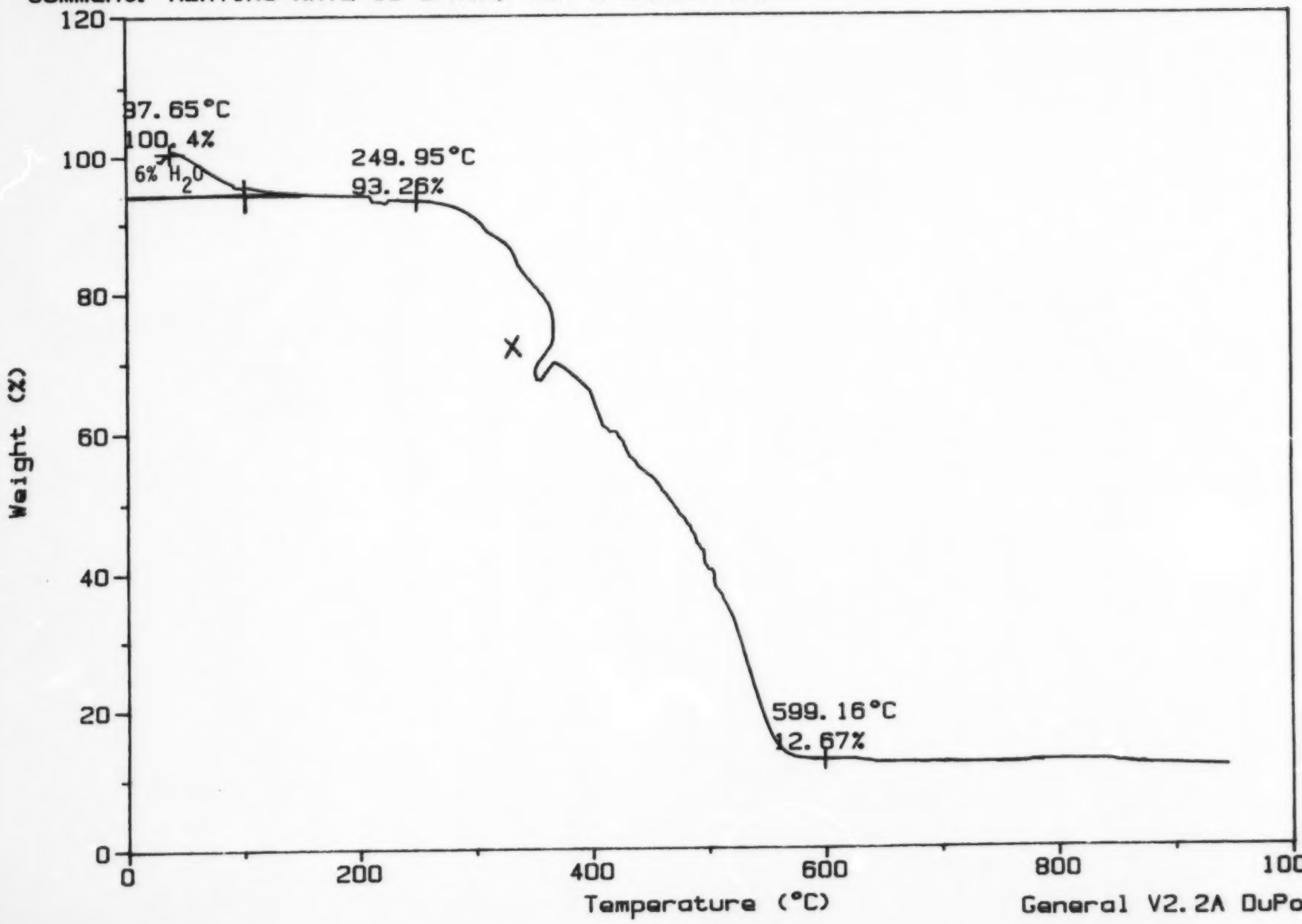
G. M. Freeman
Operations Manager
Mineral Resources

TGA 1

TGA

Sample: COAL W.O.#30904
Size: 21.9090 mg
Method: TGA-WEIGHT LOSS
Comment: HEATING RATE 10°C/MIN. AIR @ 100CC/MIN.

File: COAL.07 MIXTURE
Operator: S.V.HANNAH
Run Date: 05/22/87 14:36



General V2.2A DuPont 9900

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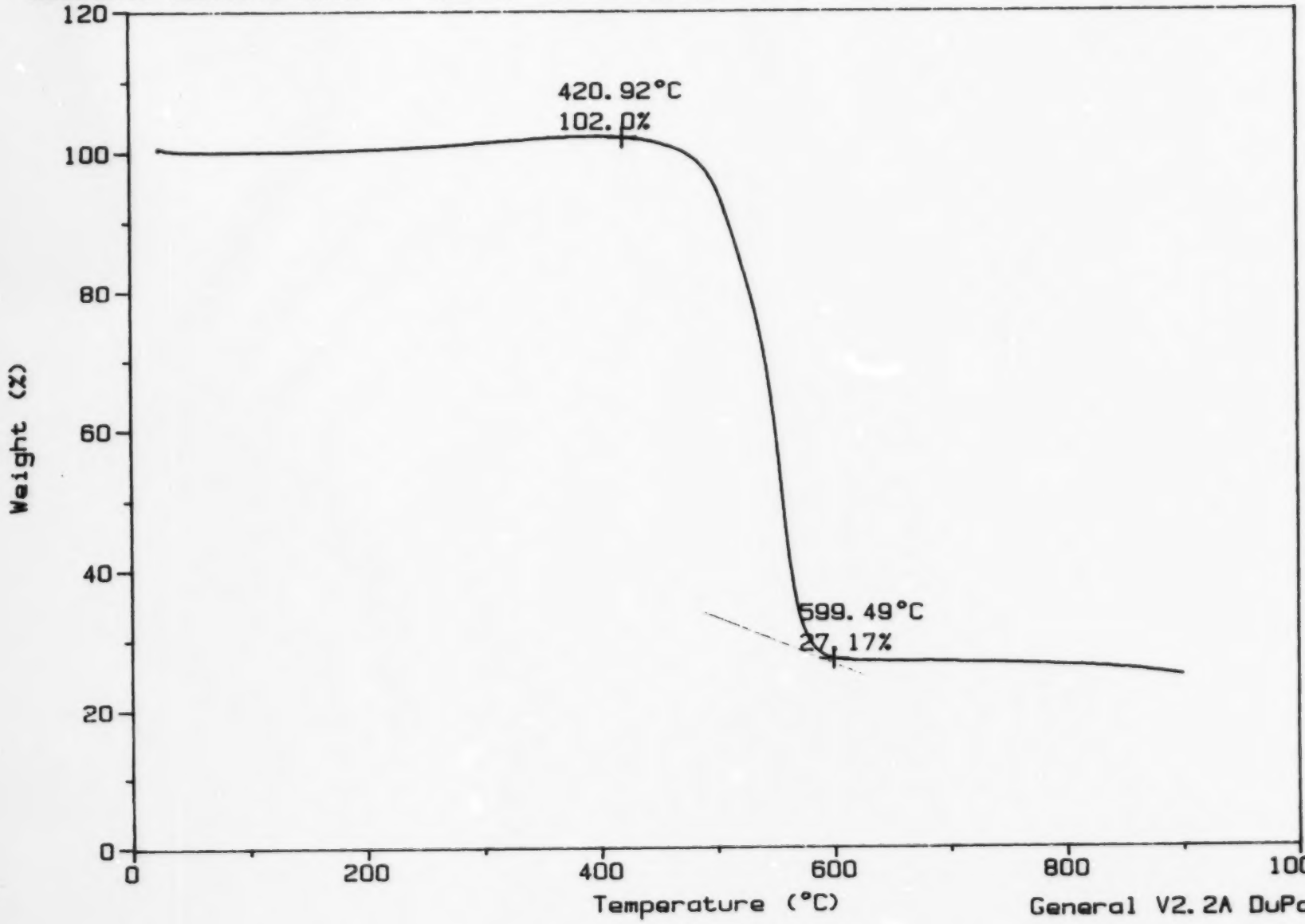
TGI 2

TGA

Sample: CHAR 73
Size: 3.6240 mg
Method: TGA-WEIGHT LOSS
Comment: HEATING RATE 10°C/MIN. AIR @ 100CC/MIN.

File: CHAR.01
Operator: S. V. HANNAH
Run Date: 05/25/87 08:37



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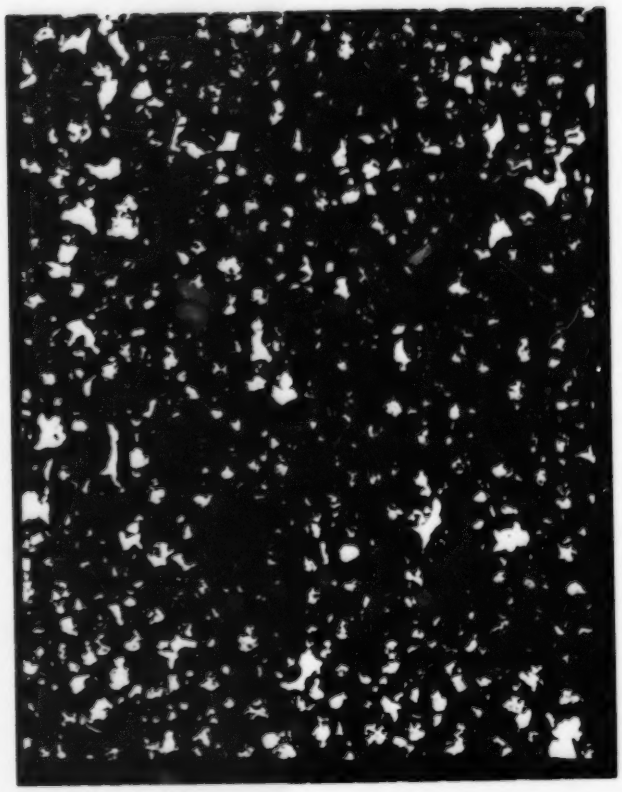

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energy conservation programs and analyses, thermal insulation design and evaluation, waste heat recovery, building energy systems and monitoring, heat storage systems and materials, thermoelectric generation, combustion technology, burner development, heat transfer analysis, solar systems monitoring, National Solar Test Facility, solar technology, wind power, coal, lignite and oil sands processing, alternate fuel utilization, battery and fuel cell technology, peat processing and utilization, fenestration measurements, heat pump development and test facilities, residential heating systems, air to air heat exchange test facility, photovoltaic devices, . . .

Environment

ambient air quality assessment, environmental impact assessments, long-range transport of atmospheric pollutants, precipitation chemistry, particulate characterization studies, emission inventories, source sampling, odour emission and control, asbestos measurement and control, occupational health and safety studies, diesel emission control technology, air pollution control, pesticide residues, trace metal analysis, trace organic analysis, radionuclide analysis, mutagenic testing, noise and vibration analysis, radiation measurements, particulate identification and measurement, water surveys, water purification, industrial and municipal wastewater treatment, membrane separation techniques, wet oxidation, solid waste treatment and recovery, hazardous waste treatment and disposal, indoor air quality assessments, priority pollutant analysis, landfill technology, . . .

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building materials, plastics, composites, metals, glass and ceramics, wood and wood composites, biomaterials, adhesives and printing inks, fibres, yarns, fabrics and geotextiles, leather, organic and inorganic chemicals, specification development, quality assurance, mechanical, chemical and thermal properties, test method development, failure analysis, fire and flammability, glass-metal seals, metal and alloy powders, metallography, materials characterization, materials characterization by optical and electron microscopy and X-ray microanalysis, photovoltaic materials, materials corrosion resource centre, corrosion properties and control, bacterial corrosion, coatings and sealants, rubber technology, X-ray analysis, cement and concrete, soils and aggregates, gypsum, body armour testing, footwear, paper-making materials, roofing and waterproofing, waste material stabilization and solidification, . . .

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